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UNITED STATES
DEPARTMENT OF AGRICULTURE
DEPARTMENT CIRCULAR No. 378

Washington, D. C.

March, 1926

COMPARATIVE HARDINESS OF WINTER-WHEAT VARIETIES

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IMPORTANCE OF HARDINESS IN WINTER WHEATS

Low temperatures cause nearly as great losses to the wheat crop in the United States as all wheat diseases combined. During the 14-year period from 1909 to 1922, inclusive, frosts or freezing caused an average loss of 3.5 per cent of the wheat crop and plant diseases 3.9 per cent, according to crop correspondents of the United States Department of Agriculture. The acreage of winter wheat abandoned, which is to a considerable extent a result of winterkilling, varies from 1.1 to 28.9 per cent annually, with an average abandonment of 9.9 per cent during the 23-year period from 1901 to 1923, inclusive (1, p. 606).¹

With a few exceptions winter wheat is more productive than spring wheat in all parts of this country where it survives the winter. The longer period of growth, together with the earlier maturity of winter wheat, which often enables it to evade injury from rust and drought, probably are the principal factors in causing the higher yields of winter wheat in comparison with spring wheat. The growing of

¹ Serial numbers in italic in parentheses refer to "Literature cited," at the end of this circular.

winter wheat also permits a better distribution of labor than if spring grains only are grown.

The reduction of losses due to winterkilling where these wheats are now grown and the northward extension of the winter-wheat area would result in both increased yields and more economical production.

Winter injury may be reduced by the use of hardy varieties and by certain cultural practices, such as sowing in stubble or cornstalks, sowing in the furrow, sowing at proper rates and dates, and mulching the wheat with straw. The first method, involving the use of hardy varieties, is discussed in this circular. The testing of many varieties and strains of wheat in northern sections where winterkilling frequently occurs has resulted in the discovery of considerable hardiness in several varieties. In order to determine the comparative hardiness of these more accurately, the sowing of a uniform set of varieties at a number of field stations was begun in the fall of 1919. The results obtained from these nurseries during six seasons are presented here, together with an account of the origin and value of the more hardy varieties.

DIFFERENCES IN COLD RESISTANCE OF WINTER-WHEAT VARIETIES

It is a common observation that wheat varieties differ in winter hardiness. Experiences of farmers have resulted in the elimination of tender varieties from the Northern States. The introduction of hard red winter wheats has resulted in a northward extension of winter-wheat growing, because of the hardiness of this class of wheats. Differences in the hardiness of wheat varieties have been reported by many investigators in Europe and in this country.

The development of hardy winter-wheat varieties in Europe has been investigated, particularly in Sweden and Russia. Only the relatively hardy varieties of winter wheat can be grown in most parts of Russia. Attempts have been made to obtain varieties having greater hardiness by the selection of surviving plants and by means of hybridization between wheat and rye. The winterkilling of wheat occurs in Sweden in some years. Observations of the relative survival of varieties and hybrids there have shown that some varieties suffer little injury, whereas others are completely winterkilled. Some selections from hybrids had a higher survival than either of the parent varieties, showing that increased hardiness can be obtained by hybridization. The hardiest varieties grown in Sweden, however, are less hardy than the hard red winter wheats grown in the United States and Russia. In the United States the hardy varieties now grown either were introduced from Russia or are the result of selections or hybrids from the introduced varieties. The origin of these varieties is discussed later.

Eriksson (4) has summarized many data on the winter hardiness of wheats grown in Sweden from 1890 to 1901. Observations were made on about 146 sorts, which included native wheats of Sweden as well as numerous foreign introductions. The Australian forms were found not inferior to the European sorts as to cold resistance. The varieties were described as 0=no resistance, 1=fair, 2=good, 3=very good power of resistance. Winterkilled plants are described as having been lifted out of the ground with the roots torn off.

Nilsson-Ehle (8) has presented data on the winter hardiness of wheats tested at Svalof and Ultuna, Sweden, from 1887 to 1906. Weather conditions for each year are described. The same author (9) found that many varieties of wheat are heterozygous with regard to cold resistance. Some of these differences are very small; that is, there is a whole series of gradations between the most and the least resistant forms. Types having different degrees of resistance to cold can not be distinguished morphologically.

De Vilmorin (12) classified 73 varieties of wheat according to resistance to cold at Paris, France, in the winter of 1916-17. The wheats were grouped into five classes, based upon the extent of winter injury.

Åkerman (2) showed the relative cold resistance of several varieties of wheat in Sweden and discussed some of the factors determining cold resistance.

Several American investigators have reported on the survival of a number of wheat varieties.

Lyon (7) observed the winter injury of more than 100 varieties of wheat grown at Lincoln, Nebr., during the five-year period from 1897 to 1901. The relative hardiness of the hard red winter varieties, particularly Turkey, was fully demonstrated.

Salmon (10) showed slight differences in survival between varieties of hard red winter wheat in South Dakota.

Spragg (11) presented data on the cold resistance of winter wheats grown at the Michigan station during the winters of 1909-10 and 1911-12. A group of Australian varieties was entirely killed.

Hume, Champlin, and Morrison (6) reported the survival of several varieties of winter wheat at Highmore, S. Dak., during a three-year period, showing that Turkey and Kharkof were the hardiest varieties tested.

Salmon² recorded the winter survival of a rather large number of strains grown in the cereal nursery at the Kansas station in the spring of 1917, following the very severe winter of 1916-17. Winter rye had a perfect survival, Buffum No. 17 a survival of 88 per cent, and strains of the Crimean group of hard red winter wheats varied from 48 to 76 per cent. The varieties of soft red winter wheat were much more injured by the cold, as indicated by the following survival percentages: Fultz, 40; Zimmerman, 36; Nebraska, No. 28, 25; Harvest Queen, 23; Currell, 16; Miracle, 3; Illini Chief, 1.

Hayes and Garber (5) have described some of the winter-wheat breeding work which has been in progress at the Minnesota station since 1898. Odessa, Big Frame, Padui, certain Minnesota strains of Turkey, and two Turkey × Odessa crosses, Minhardi and Minturki, proved to be most winter hardy. These investigators call attention to the necessity of a careful study of the hardiness of the parent sorts before making extensive crosses. They found that the types which excel in hardiness generally excel in yield under Minnesota conditions.

Clark and Martin (3) presented data on the comparative survival of 38 varieties and strains of winter wheat grown at eight experiment stations during three or more years in which partial winterkilling occurred. Buffum No. 17, Minhardi, and a strain of Turkey showed the highest survival.

²Salmon, S. C. Unpublished data, Kans. Agr. Exp. Sta., 1917.

Experiments in breeding wheats for winter hardiness are in progress in most of the North Central States. The experiment stations in these States and the United States Department of Agriculture are engaged on this problem.

The hardiness or lack of hardiness of certain varieties of winter wheat has been discussed along with other results from experiments with wheat varieties. The hard red winter wheats of the Crimean group have long been known to be hardier than other wheats, and very few wheats of other classes can be grown successfully in the northern Great Plains States. Considerable variation in hardiness exists among different varieties and strains of hard red winter wheat, as shown in this and previous publications.

Several agricultural experiment stations have selected or produced varieties by crossing which are considerably hardier than the ordinary hard red winter wheats. The need for more definite information in regard to the relative hardiness of certain varieties led to the inauguration of the present experiments.

SCOPE OF THE INVESTIGATIONS

The experiments here reported were conducted at 26 experiment stations during the six years from 1920 to 1925, inclusive. Preliminary tests of several of the hardy varieties at a few stations had been made during the winter of 1918-19. Not all the varieties were grown at all stations during all seasons, but results were obtained during a total of 111 station years. Uniform quantities of seed of each variety were prepared and sent to the various stations for sowing. Each variety was sown in triplicated rod rows. In the experiments of the first five years the seed from all varieties with a few exceptions was grown at the Kansas Agricultural Experiment Station, Manhattan, during the year it was sown. If there was not sufficient seed of any variety, seed from other sources was added to that grown at Manhattan. Most of the new varieties when added to the experiment were grown from seed at stations other than Manhattan. The 1925 nurseries were sown mostly from seed produced at North Platte, Nebr., in 1924.

The location of the uniform nurseries, the number of years the nursery was grown at each experiment station, and the names of the cooperators who obtained the data are shown in Table 1.

The sowing of the wheat and the determination of the survival of the varieties were handled by the cooperators at their respective stations,³ as shown in Table 1.

The survival percentages were determined either by an estimation of the stands of plants in fall and spring or by actual counts of plants in all or portions of a row. The survivals reported are nearly all averages of the three rows of each variety. The data on survival are presented in Tables 2 to 8, inclusive.

³ At Manhattan and Hays, Kans., Akron, Colo., North Platte, Nebr., Ames, Iowa, St. Paul, Minn., Highmore, S. Dak., Mandan and Dickinson, N. Dak., Moccasin, Mont., and Ithaca, N. Y., the experiments with wheat were in cooperation with the Office of Cereal Investigations during all the years in which the winter-hardiness nurseries were grown at these stations. At Cheyenne, Wyo., and Brookings, S. Dak., the experiments with cereals were cooperative during part of the period of these tests.

At Bozeman, Mont., and Pullman, Wash., some cereal experiments, but not the winter-hardiness nurseries, have been cooperative. The data from Colby, Kans., Lincoln, Nebr., Ashland, Wis., Redfield, S. Dak., Fargo, N. Dak., Havre, Mont., and the five stations in Canada—Ste. Anne de Bellevue (Macdonald College), Quebec; Ottawa, Ontario; Saskatoon, Saskatchewan; and Edmonton and Lethbridge, Alberta—were furnished by the courtesy of these stations and the persons listed in Table 1.

The assistance of those who supplied the data from each of the 26 stations is gratefully acknowledged.

TABLE 1.—Location of the stations, the number of years that the uniform winter-hardiness nursery was grown at each station, and the cooperators who obtained the survival data from 26 experiment stations in the United States and Canada during one to six years

Station	Years grown	Cooperators	Station	Years grown	Cooperators
UNITED STATES			UNITED STATES— Continued		
Manhattan, Kans.	6	John H. Parker.	Moccasin, Mont.	6	R. W. May.
Hays, Kans.	6	A. F. Swanson.	Bozeman, Mont.	5	H. R. Sumner, I. J. Jensen.
Colby, Kans.	3	B. F. Barnes.	Havre, Mont.	1	M. A. Bell.
Akron, Colo.	5	F. A. Coffman.	Pullman, Wash.	2	E. F. Gaines.
Cheyenne, Wyo.	6	A. L. Nelson.	Ithaca, N. Y.	6	H. H. Love.
North Platte, Nebr.	2	L. L. Zook, G. F. Sprague.	CANADA		
Lincoln, Nebr.	5	T. A. Kieselbach.	Ste. Anne de Bellevue, Quebec.	2	R. Summerby.
Ames, Iowa.	5	L. C. Burnett.	Ottawa, Ontario.	2	L. H. Newman, A. G. O. Whiteside.
Ashland, Wis.	6	E. J. Delwiche.	Saskatoon, Saskatchewan.	6	Manley Champlin, J. B. Harrington.
St. Paul, Minn.	5	H. K. Hayes, O. S. Aamodt.	Edmonton, Alberta	5	G. H. Cutler.
Brookings, S. Dak.	6	Matthew Fowlds.	Lethridge, Alberta.	1	W. D. Hay.
Highmore, S. Dak.	1	E. S. McFadden.			
Redfield, S. Dak.	1	Samuel Garver.			
Fargo, N. Dak.	6	L. R. Waldron.			
Mandan, N. Dak.	6	J. C. Brinsmade, jr.			
Dickinson, N. Dak.	6	R. W. Smith.			

Rather extensive hybridization experiments, many of them in cooperation with the Office of Cereal Investigations, are now in progress at experiment stations in the Great Plains. In these experiments use has already been made of the data on winter hardiness obtained in the experiments here reported, and the most hardy varieties, such as Minhardi, Minturki, Odessa, and Buffum No. 17, have been crossed with such standard sorts as Turkey, Kharkof, and Kanred in the hope of combining the desirable characters of the two groups of varieties.

RESULTS OBTAINED

The survival percentages for each variety at each station and the averages for each variety each year are shown in Tables 2 to 7, inclusive. The results are summarized in Table 8. It is seen that at some stations there was complete killing of all varieties. At other stations all varieties showed complete survival. At still other stations either the survival or the killing was nearly complete. At the remaining stations, where partial killing of nearly all varieties occurred, most of the useful and significant data on hardiness were obtained. The differences between the average survival percentages determined by including data from all stations are rather slight, because of the inclusion of the survival percentages from stations where killing was extremely heavy or extremely light.

Two sets of averages are given for each year, one for all stations and the other for certain stations from which the most significant data were obtained. In the latter averages the data were excluded from those stations where no killing occurred, where all varieties were completely killed, and also from Ithaca, N. Y., and Pullman, Wash., where the effects and probably the causes of killing differed from the other stations, as indicated by the survival of certain varieties. At Ithaca and Pullman the winters are relatively mild compared with the other stations, and the survival percentages

recorded appear to be measures of adaptation and vigor rather than of resistance to cold.

Probable errors or other statistical constants for the average survival percentages during individual seasons or all seasons are not given, because the ordinary statistical methods are not applicable to the data obtained. The writers believe, however, that there is no question of the significance of the differences in hardiness of such varieties as Minhardi, Minturki, Odessa, and Buffum No. 17, which are more hardy than the standard Kharkof, or of the lower degree of cold resistance of such varieties as Blackhull and Nebraska No. 28. It is doubtful whether the determination of probable errors would make it possible to draw trustworthy conclusions as to the significance of minor differences, such as those between different strains of Kharkof or between Kanred and the strains of Turkey other than Cereal Investigations (C. I.) No. 6152.

TABLE 2.—Average survival in the spring of 1920 of 22 varieties of winter wheat grown in triplicated rod rows to determine winter hardiness at 13 experiment stations in the northern United States and in Canada during the winter of 1919-20

[Details from Dickinson and Mandan, N. Dak., and Saskatoon, Saskatchewan, where killing of all varieties was complete, are omitted from the table]

Class and variety	C. I. No.	State No.	Survival (per cent)										Average for—	
			Manhattan, Kans.	Hays, Kans.	Akron, Colo.	Archer, Wyo.	Ashland, Wis.	Brookings, S. Dak.	Highmore, S. Dak.	Fargo, N. Dak.	Moccasin, Mont.	Ithaca, N. Y.	13 sta-	9 sta-
													tions ¹	tions ²
HARD RED WINTER														
Kharkof.....	1442		100	100	1	7	59	0	0	0	1	27	22.7	29.8
Montana No. 36.....	5549		100	100	3	3	40	5	10	2	10	26	23.0	30.3
Turkey (selection).....	6152	Minn. 1488.....	100	100	2	4	37	5	10	17	1	35	23.9	30.7
Do.....	6472	Kans. 1664.....	100	100	1	7	64	0	0	1	1	34	23.7	30.4
Turkey.....	4428	Kans. 2242.....	100	100	1	1	63	0	0	1	1	35	23.2	29.7
Nebraska No. 60.....	6250		100	100	4	0	18	5	5	7	2	21	20.2	26.8
Turkey (selection).....	2636	Kans. 2283.....	100	100	2	7	63	1	0	5	1	35	24.2	31.0
Do.....	2636	Kans. 2284.....	100	100	2	2	63	0	0	5	0	45	24.4	30.2
Beloglina.....	1667		100	100	2	8	60	5	0	3	1	29	23.7	31.0
Kanred.....	5146	Kans. 2401.....	100	100	2	0	60	1	1	1	3	24	22.5	29.8
P-1068.....	5880	Kans. 2414.....	100	100	1	0	61	1	1	2	2	30	22.9	29.8
P-1066.....	5879	Kans. 2415.....	100	100	1	5	47	1	1	1	4	24	21.8	28.9
Torgova.....	1539	Kans. 2264.....	100	100	1	14	67	1	0	3	0	38	24.9	31.8
Hornblende×Summer Club.....	445	Kans. 2312.....	100	100	1	1	39	10	1	7	0	21	21.5	28.8
Crimean selection (awnless).....	1443	Kans. 2402.....	100	100	2	7	36	1	0	4	2	27	21.5	28.0
Baesa.....	6156	Wis. Ped. 408.....	100	95	1	6	25	0	0	5	1	35	20.6	25.9
Padui.....	6153	Minn. 1491.....	100	100	1	5	38	5	5	12	4	34	23.4	30.0
Minturki.....	6155	Minn. 1507.....	100	100	2	0	54	5	3	9	7	24	23.4	31.1
SOFT RED WINTER														
Minhardi.....	5149	Minn. 1505.....	100	100	5	9	44	10	1	35	33	22	27.6	37.4
Odessa.....	6151	Minn. 1471.....	100	100	8	13	41	5	1	23	1	40	25.5	32.4
Buffum No. 17.....	3330		100	100	3	2	21	10	1	60	2	34	25.6	33.2
Nebraska No. 28.....	5147		90	95	1	0	27	0	0	1	0	24	18.3	23.8

¹ Average for 13 stations includes Dickinson and Mandan, N. Dak., and Saskatoon, Saskatchewan, where complete killing occurred.

² Excluding Ithaca, N. Y., where killing effects are not comparable with the other stations.

RESULTS IN 1920

Winter-hardiness nurseries were sown in 1920 at 12 stations in the United States and at Saskatoon, Saskatchewan, Canada, in the fall of 1919. The survival data are shown in Table 2. Complete killing occurred at Dickinson and Mandan, N. Dak., and at Saskatoon. Considerable killing occurred at all stations except at Manhattan and Hays, Kans. Minhardi, Buffum No. 17, and Odessa showed the highest average survival for all stations, as well as for the nine stations where partial winterkilling occurred.

TABLE 3.—Average survival in the spring of 1921 of 18 varieties or strains of winter wheat grown in triplicated rod rows to determine winter hardiness at 17 experiment stations in the northern United States and in Canada during the winter of 1920-21

[T=trace. Details from Akron, Colo., and Lincoln, Nebr., where survival of all varieties was complete, and from Mandan, N. Dak., and Saskatoon, Saskatchewan, where killing was complete, are omitted from the table]

Class and variety	C. I. No.	State No.	Survival (per cent)													Average for —	
			Manhattan, Kans.	Hays, Kans.	Archer, Wyo.	Ames, Iowa	Ashland, Wis.	St. Paul, Minn.	Brookings, S. Dak.	Fargo, N. Dak.	Dickinson, N. Dak.	Moccasin, Mont.	Bozeman, Mont.	Ithaca, N. Y.	Edmonton, Alberta	17 stations ¹	12 stations ²
HARD RED WINTER																	
Kharkof.....	1442		100	75	13	99	74	98	90	100	0	83	99	68	93	70.3	77.3
Karmont.....	6700		100	75	38	97	71	98	97	98	0	68	96	62	93	70.4	77.8
Montana No. 36..	5549		100	74	40	97	78	97	97	100	0	87	96	72	90	72.4	79.7
Turkey (selection)	6152	Minn. 1488..	100	100	60	100	51	100	83	100	1	75	100	90	98	75.5	83.2
Do.....	6472	Kans. 1664..	100	72	50	99	76	100	97	100	1	70	97	79	94	72.6	79.7
Nebraska No. 60..	6250		100	96	40	90	77	100	95	100	T	72	100	73	99	73.1	80.8
Banat (selection)	6676	Iowa 1946..	100	66	8	99	70	90	92	100	0	55	100	72	94	67.4	72.8
"Station Red"	6467	Wash. 1093..	100	60	27	99	71	98	97	93	T	33	99	66	92	66.6	72.4
Belogolina.....	1657		100	96	54	98	76	100	100	100	T	85	99	82	97	75.7	83.6
Kanred.....	5149	Kans. 2401..	100	50	50	99	78	96	98	100	1	40	99	81	98	71.8	78.3
Blackhull.....	6251		100	60	25	97	69	73	68	52	0	32	96	77	70	59.9	61.8
Bacska.....	6156	Wis. Ped. 408..	100	68	40	98	74	73	53	90	T	62	100	81	92	66.5	70.8
Padui.....	6153	Minn. 1491..	100	87	33	100	81	100	95	100	0	87	100	71	99	73.7	81.8
Minturki.....	6155	Minn. 1567..	100	99	40	100	87	100	95	100	1	90	100	77	98	75.7	84.2
SOFT RED WINTER																	
Minhardi.....	5149	Minn. 1505..	100	99	37	99	88	100	97	100	2	92	99	69	99	75.4	84.3
Odessa.....	6151	Minn. 1471..	100	93	27	99	89	100	93	100	1	70	100	79	98	73.5	80.8
Buffum No. 17..	3330		100	100	37	93	93	100	89	100	1	100	100	68	89	74.7	83.5
Nebraska No. 28..	5147	Nebr. 28.....	80	47	30	92	77	95	60	98	0	68	99	70	76	64.2	68.5

¹ Average for 17 stations includes Akron, Colo., and Lincoln, Nebr., where no killing occurred; Mandan, N. Dak., and Saskatoon, Saskatchewan, where complete killing occurred.

² Excluding Ithaca, N. Y., where killing effects are not comparable with other stations.

RESULTS IN 1921

Eighteen varieties of wheat were sown in the winter-hardiness nurseries in the fall of 1920 at 17 experiment stations. Four varieties were added to the list and 8 varieties were dropped. The experiment was discontinued at Highmore, S. Dak. and 5 new stations were added to the list. The average winter survival was much higher in 1921 than in 1920. (Table 3.) Complete killing occurred at Mandan, N. Dak., and Saskatoon, Saskatchewan, with no killing at Akron, Colo., and Lincoln, Nebr. The Minhardi, Minturki, Belo-

glina, and Buffum No. 17 varieties showed the highest average survivals at the 12 stations. The seed sown for Buffum No. 17 proved to be a mixture of about two-thirds Kanred and one-third Buffum No. 17 when the plants headed in 1921. Seed of the two varieties apparently had been accidentally mixed after threshing. The survival percentages shown for Buffum No. 17 are therefore corrected according to the survival of Kanred by assuming the above-mentioned proportions. At Archer, Wyo., and Ithaca, N. Y., the results show that Buffum No. 17 and the varieties adjacent to it were under more severe conditions, so at these two stations the survivals shown are those for Minhardi, which has only a slightly higher average survival than Buffum No. 17. Blackhull wheat had a lower average survival percentage than any other variety, even lower than Nebraska No. 28, which was known to be a tender sort.

TABLE 4.—Average survival in the spring of 1922 of 20 varieties or strains of winter wheat grown in triplicated row rows to determine winter hardiness at 16 experiment stations¹ in the northern United States and in Canada during the winter of 1921-22

[T=trace.—Details from Manhattan, Kans., and Moccasin, Mont., where survival of all varieties was complete, and from Mandan, N. Dak., and Edmonton, Alberta, where killing was complete, are omitted from the table]

Class and variety	C. I. No.	State No.	Survival (per cent)													Average for 16 stations ²	Average for 11 stations ³
			Akron, Colo.	Archer, Wyo.	Lincoln, Nebr.	Ames, Iowa	Ashland, Wis.	St. Paul, Minn.	Brookings, S. Dak.	Fargo, N. Dak.	Dickinson, N. Dak.	Bozeman, Mont.	Ithaca, N. Y.	Saskatoon, Saskatchewan			
HARD RED WINTER																	
Kharkof	1442		33	7	100	98	98	13	63	35	0	97	52	8	50.3	50.2	
Karmont	6700		30	8	100	98	99	15	53	26	0	100	55	2	49.1	48.3	
Montana No. 36	5549		31	8	100	98	99	17	60	30	0	99	57	3	50.1	49.5	
Turkey (selection)	6152	Minn. 1488	34	3	100	100	100	25	75	49	0	99	61	8	53.4	53.9	
Do	6472	Kans. 1664	29	11	100	99	97	13	57	12	0	100	56	4	48.6	47.5	
Nebraska No. 60	6250		37	7	100	100	100	18	67	35	0	98	54	5	51.3	51.5	
"Station Red"	6467	Wash. 1093	28	T	100	100	99	16	50	5	0	99	45	28	48.1	47.7	
Beloglina	1667		31	2	100	100	98	15	70	30	0	94	50	3	49.6	49.4	
Kanred	5146	Kans. 2401	30	12	100	100	99	13	60	19	0	98	53	1	49.1	48.4	
Bacska	6156	Wis. Ped. 408	24	0	100	96	96	10	10	2	0	99	51	0	43.0	39.7	
Blackhull	6251		21	1	100	96	99	2	22	0	0	99	51	8	43.7	40.7	
Banat (selection)	6676	Iowa 1946	31	2	100	100	96	8	75	29	0	98	54	2	49.7	49.2	
Malakof (selection)	6680	Wis. 11-825	30	1	100	99	99	15	88	11	0	99	58	10	50.6	50.2	
Padui	6153	Minn. 1491	20	3	100	99	98	75	95	19	0	98	48	22	54.8	57.2	
Eureka	5170		38	1	99	98	98	8	37	1	0	100	56	1	46.1	43.7	
Minturki	6155	Minn. 1507	23	3	100	100	99	47	95	81	1	99	52	22	57.6	60.9	
SOFT RED WINTER																	
Minhardi	5149	Minn. 1505	36	3	100	100	98	92	100	87	2	96	49	27	61.9	67.4	
Buffum No. 17	3330		20	2	100	93	97	63	78	57	3	93	46	27	54.9	57.5	
Odessa	6151	Minn. 1471	20	2	100	100	97	43	87	45	1	94	64	23	54.8	55.6	
Nebraska No. 28	5147	Nebr. 28	21	3	100	100	98	9	37	2	0	98	49	5	45.1	43.0	

¹ Wheat did not emerge until spring at Hays, Kans., and no data were obtained.

² Average for 16 stations, includes Mandan, N. Dak., and Edmonton, Alberta, where complete killing occurred; Manhattan, Kans., and Moccasin, Mont., where no killing occurred.

³ Excluding Ithaca, N. Y., where killing effects are not comparable with other stations.

RESULTS IN 1922

Twenty varieties of wheat were sown in the uniform winter-hardiness nurseries at 17 experiment stations in the fall of 1921. Winterkilling was complete at Mandan, N. Dak., and Edmonton,

Alberta. Very heavy killing occurred at Dickinson, N. Dak., and Archer, Wyo. No killing occurred at Manhattan, Kans., and Moccasin, Mont. The Eureka variety alone showed killing at Lincoln, Nebr. Minhardi again showed the highest average survival, followed by Minturki, Buffum No. 17, Padui, and Odessa. Bacska and Blackhull showed the lowest survival. Data from Hays, Kans., are not shown, because the wheats did not emerge until spring. The results obtained in 1922 are presented in Table 4.

TABLE 5.—Average survival in the spring of 1923 of 24 varieties or strains of winter wheat grown in triplicated rod rows to determine winter hardiness at 16 experiment stations¹ in the northern United States and in Canada during the winter of 1922-23

[T=trace. Details from Manhattan, Kans., and Lincoln, Nebr., where survival of all varieties was complete, and from Fargo, Mandan, and Dickinson, N. Dak., and Saskatoon, Saskatchewan, where killing was complete, are omitted from the table]

Class and variety	C. I. No.	State No.	Survival (per cent)											
			Hays, Kans.	Colby, Kans.	Archer, Wyo.	Ames, Iowa	Asbland, Wis.	St. Paul, Minn.	Brookings, S. Dak.	Bozeman, Mont.	Ithaca, N. Y.	Edmonton, Alberta	Average for 10 stations ²	Average for 9 stations ³
HARD RED WINTER														
Kharkof.....	1442	-----	33	70	8	97	51	42	0	98	71	0	41.9	44.3
Montana No. 36.....	5549	-----	36	60	12	95	37	37	0	98	71	0	40.4	41.7
Karmont.....	6700	-----	32	68	12	97	44	31	0	98	69	0	40.7	42.4
Kharkof (selection).....	6686	Hays No. 2.....	46	76	14	98	62	62	0	98	62	0	44.9	50.7
Turkey (selection).....	6152	Minn. 1488.....	37	45	24	92	46	86	0	98	70	1	43.7	47.7
Do.....	6472	Kans. 1664.....	38	46	16	97	40	48	0	98	68	T	40.7	42.6
Nebraska No. 6.....	6249	-----	32	71	11	97	55	53	0	98	69	0	42.9	46.3
Nebraska No. 60.....	6250	-----	37	51	16	95	47	63	0	98	63	T	41.9	45.2
"Station Red".....	6467	Wash. 1093.....	27	73	7	95	46	43	0	95	72	0	41.1	42.9
Sherman.....	4430	-----	17	38	2	98	39	1	0	99	62	0	34.8	32.7
Beloglina.....	1667	-----	28	75	21	97	46	89	0	97	67	0	45.0	50.3
Kanred.....	5146	Kans. 2401.....	48	89	14	94	46	60	0	97	69	0	44.8	49.5
Malakof (selection).....	6650	Wis. 11-825.....	38	65	14	98	51	92	0	98	73	0	45.6	50.7
Hussar.....	4843	-----	13	17	2	94	33	1	0	96	62	0	32.4	28.4
Blackhull.....	6251	-----	13	41	T	87	19	2	0	96	73	0	33.2	28.7
Bacska.....	6156	Wis. Ped. 408.....	13	29	1	92	32	7	0	95	70	0	33.7	29.9
Padui.....	6153	Minn. 1491.....	34	72	5	96	52	96	0	96	74	1	45.4	50.2
Banat (selection).....	6676	Iowa 1946.....	25	57	17	97	38	65	0	97	64	0	41.3	44.0
Eureka.....	5170	-----	27	49	7	90	39	3	0	96	79	0	36.9	34.6
Minturki.....	6155	Minn. 1507.....	41	71	16	98	62	95	2	98	68	1	47.0	53.8
SOFT RED WINTER														
Minhardi.....	5149	Minn. 1505.....	45	92	12	96	53	100	3	98	76	1	48.5	55.6
Buffum No. 17.....	3330	-----	38	74	35	99	69	99	2	98	76	1	49.4	57.2
Odessa.....	6151	Minn. 1471.....	34	55	11	99	54	92	1	97	80	1	45.3	49.3
Nebraska No. 28.....	5147	-----	23	66	1	84	35	6	0	98	77	0	36.9	34.8

¹ Wheat did not emerge until spring at Akron, Colo., and Moccasin, Mont., and no data were obtained.

² Average for 16 stations includes Manhattan, Kans., and Lincoln, Nebr., where no killing occurred; Fargo, Mandan, and Dickinson, N. Dak., and Saskatoon, Saskatchewan, where complete killing occurred.

³ Excluding Ithaca, N. Y., where killing effects are not comparable with other stations.

RESULTS IN 1923

The winter-hardiness nurseries containing 24 varieties were sown at 18 experiment stations in the fall of 1922. No killing occurred at Manhattan, Kans., and Lincoln, Nebr. Complete killing occurred at Fargo, Mandan, and Dickinson, N. Dak., and Saskatoon, Saskatchewan. Almost complete killing occurred at Brookings, S. Dak., and Edmonton, Alberta. The wheat sown at Akron, Colo., and Moccasin, Mont., did not emerge until spring, and for this reason survival percentages could not be determined. After omitting the

data from Ithaca, N. Y., and those stations at which partial-killing data could not be obtained, only 9 stations remained to be included in the comparable averages.

Buffum No. 17 showed the highest average survival for the season, followed by Minhardi and Minturki. Six varieties had average survivals between 49 and 51 per cent. The data obtained in 1923 are given in Table 5.

Sherman and Hussar, two strains of particular interest because of their resistance to bunt, or stinking smut, proved to be much less hardy than the standard Kharkof. The 1923 results show that Blackhull is even less hardy than Nebraska No. 28, the variety first used as a nonhardy check in these experiments.

RESULTS IN 1924

In 1924, the winter-hardiness nurseries contained 27 varieties of wheat sown at 22 stations. No killing occurred at North Platte and Lincoln, Nebr., Ames, Iowa, and St. Paul, Minn. Severe killing occurred at Fargo and Mandan, N. Dak., and Saskatoon, Saskatchewan, but killing was not complete at any station. In Table 6 in the averages for the stations where partial killing occurred the results from both Pullman, Wash., and Ithaca, N. Y., are excluded because the killing effects did not appear to be comparable with those of the other stations. The average survivals of all varieties were rather high in 1924. The hardiest varieties, as shown in Table 6, were Odessa, Minhardi, Buffum No. 17, and Minturki. The two Kanred \times Marquis, or winter \times spring, crosses included in the 1924 trials proved to be less hardy than the Kharkof check and their winter-wheat parent, Kanred. As in 1923, Sherman was found to be somewhat more hardy than Hussar, but both these smut-resistant varieties are less hardy than Kharkof. With the exception of Hussar, Triplet had the lowest average survival.

RESULTS IN 1925

In 1925 the winter-hardiness nurseries contained 28 varieties sown at 24 stations. Seed of most of the wheats was from the 1924 crop at North Platte, Nebr. No killing occurred at Manhattan and Hays, Kans., and Lincoln, Nebr., but killing was complete at Mandan, N. Dak., Redfield, S. Dak., Havre, Mont., and Saskatoon, Saskatchewan. The varieties having the highest average survival at the stations where partial killing occurred were Buffum No. 17, Minhardi, Odessa, Minturki, Padui, and the Kharkof selection (Macdonald College No. 2212), in the order named. The standard Kharkof (C. I. No. 1442) survived rather poorly in 1925, so that the less hardy varieties appear relatively better than would be expected in most seasons. There was an average difference of 10.9 per cent in the survival of Nebraska No. 6 and Nebraska No. 60, the latter being the hardier. The survival percentages in 1925 are shown in Table 7.

TABLE 6.—Average survival in spring of 1924, of 27 varieties or strains of winter wheat grown in triplicated¹ rows to determine winter hardiness at 22 experiment stations in the northern United States and in Canada during the winter of 1923-24

[T=trace. Details from North Platte and Lincoln, Nebr., Ames, Iowa, and St. Paul, Minn., where survival of all varieties was complete, are omitted from the table]

Class and variety	C.I. No.	State No.	Survival (per cent)																				
			Miamhattan, Kans.	Hays, Kans.	Colby, Kans.	Alton, Colo.	Cheyenne, Wyo.	Ashland, Wis.	Brookings, S. Dak.	Fargo, N. Dak.	Mandan, N. Dak.	Dickinson, N. Dak.	Moceasin, Mont.	Bozeman, Mont.	Pullman, Wash.	Ithaca, N. Y.	Ste. Anne de Bellevue, Quebec	Ontario	Saskatoon, Saskatchewan	Edmonton, Alberta	Average 22 stations ²	Average 16 stations ³	
HARD RED WINTER																							
Kharkof.....	1442	-----	92	100	67	90	63	68	10	0	0	50	99	84	54	92	90	93	0	64	68	9	60.6
Montana No. 36.....	5549	Mont. 36.....	92	100	73	85	73	70	9	0	T	41	100	83	69	85	85	93	0	63	69	1	60.4
Karmont.....	6700	-----	91	100	73	90	67	62	9	0	0	43	98	88	50	83	90	96	0	69	68	6	61.0
Kharkof(selection)	6686	Hays No. 2.....	94	100	91	73	67	51	19	1	T	37	99	89	66	72	81	94	0	68	68	3	60.3
Do.....	6938	(*).....	94	100	87	88	52	71	12	2	1	45	99	92	95	88	75	95	0	70	71	2	61.4
Turkey (selection)	6152	Minn. 1488.....	97	100	84	90	75	68	23	0	T	51	100	93	61	90	91	95	0	86	72	9	65.8
Do.....	6472	Kans. 1664.....	95	100	76	90	80	67	14	0	0	38	98	89	64	87	79	96	0	73	70	3	62.2
Nebraska No. 6.....	6249	-----	94	100	78	77	63	61	13	1	0	59	100	92	56	82	81	92	0	67	68	9	61.1
Nebraska No. 60.....	6250	-----	94	100	77	82	77	61	16	1	1	59	100	95	62	83	85	94	0	67	70	6	63.1
Sherman.....	4430	-----	96	100	88	42	53	52	5	0	0	27	100	89	64	85	80	97	0	22	63	6	53.2
Beloglina.....	1667	-----	96	100	84	85	73	68	25	0	0	53	98	93	89	87	87	92	0	76	72	1	64.4
Kanred.....	5146	Kans. 2401.....	96	100	78	75	65	70	19	1	0	49	98	94	66	83	88	94	0	76	70	6	62.8
"Tenmarq"(Kanred X Marquis)	6936	Kans. 439.....	95	100	75	43	33	54	4	0	0	24	98	88	82	83	72	95	0	27	62	4	50.5
"Kanmarq"(Kanred X Marquis)	6937	Kans. 440.....	95	100	84	65	33	51	8	0	0	37	98	91	68	78	79	97	0	40	64	7	54.9
Hussar.....	4843	-----	92	100	60	35	37	48	1	0	0	16	98	89	62	72	77	93	0	19	59	0	47.8
Blackhull.....	6251	-----	96	100	47	30	67	53	9	0	0	44	97	93	77	82	79	95	0	27	63	5	52.3
Malakof(selection)	6680	Wis. 11-825.....	95	100	86	89	60	70	43	2	T	49	98	93	59	83	87	96	1	75	72	1	65.3
Iobred.....	6934	Iowa 1949.....	95	100	85	63	70	51	10	1	0	61	98	91	75	88	79	95	0	48	68	6	59.2
Minard.....	6690	Minn. 2199.....	97	100	85	62	83	68	15	1	4	57	99	94	87	92	66	95	0	61	71	2	61.7
Padui.....	6153	Minn. 1491.....	96	100	76	48	92	70	50	4	0	49	98	93	77	85	96	97	0	90	73	7	66.2
Newturk (Newton X Turkey)	6935	166B1-6.....	93	100	82	70	67	52	8	0	T	48	100	89	77	87	65	95	0	55	67	6	57.8
Minturki.....	6155	Minn. 1507.....	96	100	89	85	85	68	43	9	3	47	100	92	74	70	87	97	1	77	73	8	67.4
SOFT RED WINTER																							
Minhardi.....	5149	Minn. 1505.....	95	100	91	89	92	72	65	11	1	51	100	93	62	80	90	96	0	74	75	5	70.0
Buffum No. 17.....	3330	-----	95	100	88	92	60	69	42	7	2	49	100	93	50	73	93	97	2	91	72	9	67.5
Odessa.....	6151	Minn. 1471.....	98	100	84	100	75	66	45	6	T	75	100	95	60	80	96	97	3	94	76	1	70.9
Nebraska No. 28.....	5147	Nebr. 28.....	97	97	61	34	70	70	6	3	T	21	98	91	78	82	93	92	0	42	65	2	54.7
Triplet.....	5408	Wash. 597.....	91	100	69	33	33	48	2	0	0	28	100	89	77	85	75	94	0	7	60	5	48.1

¹ Duplicate rod rows only at Lincoln, Nebr.

² Average for 22 stations includes North Platte and Lincoln, Nebr., Ames, Iowa, and St. Paul, Minn., where no killing occurred.

³ Excluding Pullman, Wash., and Ithaca, N. Y., where killing effects differed from those at other stations.

⁴ Macdonald College No. 2212.

DISCUSSION OF RESULTS

The annual and weighted average percentages of winter survival of each variety which has been included in these experiments for one or more years are shown in Table 8. The percentages shown are the averages for the stations at which partial winterkilling occurred and include results from 72 station years. Although 45 varieties and strains were included in these experiments, only 11 were grown during all six seasons. (Table 9.) The survival of these 11 varieties is shown graphically in Figure 1. Ten varieties which were grown in each of the six years had a higher average survival than Kharkof (C. I. No. 1442). Statistically considered, there is a question as to the significance of the difference in hardiness between Kanred and the standard Kharkof, which had average percentages of survival of

54.4 and 52.4 per cent, respectively; but other experimental data and numerous field observations also add weight to the evidence that Kanred is slightly harder than commercial stocks of Turkey and Kharkof.

Four varieties which were grown during three to five but less than six years showed a higher percentage of survival than Kharkof. These were Malakof selection (Wis. 11-825), Nebraska No. 6, Karmont, and Turkey (C. I. No. 6472). The survivals of Karmont and Turkey (C. I. No. 6472) were nearly the same as Kharkof. A few varieties grown one or two years showed a slightly higher survival than Kharkof.

TABLE 7.—Average survival in spring of 1925 of 28 varieties or strains of winter wheat grown in triplicated¹ rod rows to determine winter hardiness at 24 experimental stations in the northern United States and in Canada during the winter of 1924-25

[T=trace. Details from Manhattan and Hays, Kans., and Lincoln, Nebr., where survival of all varieties was complete, and from Redfield, S. Dak., Mandan, N. Dak., Havre, Mont., and Saskatoon, Saskatchewan, where killing was complete, are omitted from the table]

Class and variety	C. I. No.	State No.	Survival (per cent)																		
			Colby, Kans.	Cheyenne, Wyo.	North Platte, Nebr.	Ames, Iowa	Ashland, Wis.	St. Paul, Minn.	Brookings, S. Dak.	Fargo, N. Dak.	Dickinson, N. Dak.	Moccasin, Mont.	Bozeman, Mont.	Pullman, Wash.	Ithaca, N. Y.	Ste. Anne de Bellevue, Quebec	Ottawa, Ontario	Lethbridge, Alberta	Edmonton, Alberta	Average for 24 stations ²	Average for 15 stations ³
HARD RED WINTER																					
Kharkof.....	1442		47	2	79	92	64	45	0	0	7	4	0	79	82	88	100	53	75	46.5	43.7
Kharkof (selection).....	6938	(⁴)	82	12	91	93	90	83	2	0	15	90	27	70	89	88	100	93	94	59.1	64.0
Montana No. 36.....	5549	Mont. 36.....	69	1	75	89	66	63	0	0	8	2	0	73	83	87	99	72	75	48.4	47.1
Karmont.....	6700		56	1	77	92	57	68	0	1	11	3	0	80	82	86	100	69	71	48.1	46.1
Turkey.....	3055		41	0	79	90	50	28	0	1	11	0	0	41	87	83	99	42	71	42.6	39.7
Turkey (selection).....	6152	Minn. 1488.....	84	53	92	90	67	88	0	23	82	3	56	87	89	89	100	95	79	57.8	63.0
Turkey (selection 1571C).....	7364		73	0	87	92	51	32	0	3	2	0	0	42	85	83	100	63	58	44.6	42.9
Nebraska No. 6.....	6249	Nebr. 6.....	69	3	82	88	66	70	0	0	20	4	0	69	82	83	98	82	79	49.8	49.6
Nebraska No. 60.....	6250	Nebr. 60.....	83	34	94	96	73	68	0	0	13	88	1	69	85	84	100	91	82	56.7	60.5
Sherman.....	4430		84	0	60	93	47	22	0	0	1	0	0	62	73	67	100	40	72	42.5	39.1
Beloglina.....	1543		95	5	88	99	81	86	0	2	15	58	3	77	83	88	100	91	91	56.7	60.1
Do.....	1667		95	5	85	92	73	73	0	3	13	34	1	47	80	59	100	86	81	51.1	53.3
Kanred.....	5146	Kans. 2401.....	80	4	82	93	71	68	0	2	7	8	0	90	83	69	100	50	88	49.8	48.1
Blackhull.....	6251		55	1	80	90	39	12	0	1	1	0	0	65	87	69	99	30	72	41.7	36.6
Malakof (selection).....	6680	Wis. 11-825.....	94	15	89	95	41	63	4	T	8	55	8	57	88	91	100	91	90	53.7	56.3
Iobred.....	6934	Iowa 1949.....	52	2	87	90	74	45	1	0	3	10	6	65	85	92	100	82	85	49.1	48.6
Minard.....	6690	Minn. 2199.....	87	7	83	87	80	69	0	0	12	70	12	54	82	89	100	81	92	54.4	57.9
Padui.....	6153	Minn. 1491.....	91	52	88	90	64	94	11	T	7	82	13	55	88	84	100	92	94	58.5	64.1
Newturk.....	6935	166B1-6.....	57	0	80	92	65	8	0	0	11	1	0	64	82	87	100	39	85	44.6	41.7
Minturki.....	6155	Minn. 1507.....	93	27	89	90	74	99	12	0	17	84	14	51	75	86	100	89	91	58.0	64.3
"Tenmarq".....	6936	Kans. 439.....	62	0	67	83	44	35	0	0	1	1	0	68	77	67	100	43	73	42.5	38.4
"Kanmarq".....	6937	Kans. 440.....	86	0	71	89	55	43	2	0	2	3	0	52	82	81	100	62	81	46.2	45.0
Marquis X Kanred.....		Kans. 441.....	59	0	64	73	41	14	1	0	1	1	0	69	75	79	98	47	63	41.0	36.1
Do.....		Kans. 449.....	73	0	71	90	59	42	0	0	5	1	0	63	78	83	99	42	75	45.0	42.7
P-1068 X Preston.....	8027	Kans. 446.....	57	0	79	85	59	25	1	0	5	1	0	57	75	79	97	38	79	43.2	40.3
SOFT RED WINTER																					
Minhardi.....	5149	Minn. 1505.....	97	53	88	95	68	100	13	0	17	98	38	60	87	88	100	99	92	62.2	69.7
Buffon No. 17.....	3330		98	45	91	98	67	98	9	1	27	100	61	43	88	97	100	100	96	63.3	72.5
Odessa.....	6151	Minn. 1471.....	93	30	93	98	68	96	9	0	15	88	24	70	87	94	100	99	94	60.8	66.7

¹ Duplicate rod rows only at Lincoln, Nebr.

² Average for 24 stations includes Manhattan and Hays, Kans., and Lincoln, Nebr., where no killing occurred, Mandan, N. Dak., Redfield, S. Dak., Havre, Mont., and Saskatoon, Saskatchewan, where complete killing occurred.

³ Excluding Ithaca, N. Y., and Pullman, Wash., where killing effects differed from those at other stations.

⁴ Macdonald College No. 2212.

TABLE 8.—Annual and average percentages of survival of 45 varieties of wheat grown in the uniform winter-hardiness nurseries during one or more of the six years from 1920 to 1925, inclusive

Class and variety	C. I. No.	Survival (per cent)						Average (weighted)	Khar-kof same years	Number of station years	Per-cent- age of Khar-kof
		1920 (9 stations)	1921 (12 stations)	1922 (11 stations)	1923 (9 stations)	1924 (16 stations)	1925 (15 stations)				
HARD RED WINTER											
Kharkof.....	1442	29.8	77.3	50.2	44.3	60.6	43.7	52.4	72	100.0	
Kharkof (selection).....	6938					61.4	64.0	62.7	52.4	31	119.7
Kharkof (Hays No. 2).....	6686				50.7	60.3		56.8	54.7	25	103.8
Montana No. 36.....	5549	30.3	79.7	49.5	41.7	60.4	47.1	53.1	52.4	72	101.3
Karmont.....	6700		77.8	48.3	42.4	61.0	46.1	55.8	55.6	63	100.4
Turkey (selection).....	6152	30.7	83.2	53.9	47.7	65.8	63.0	59.6	52.4	72	113.7
Turkey.....	6472	30.4	79.7	47.5	42.6	62.2		54.9	54.7	57	100.4
Do.....	4428	29.7						29.7	29.8	9	99.7
Do.....	3055						39.7	39.7	43.7	15	90.8
Turkey (selection).....	2636	31.0						31.0	29.8	9	104.0
Do.....	2636	30.2						30.2	29.8	9	101.3
Turkey (selection 1571C).....	7364						42.9	42.9	43.7	15	98.2
Nebraska No. 6.....	6249				46.3	61.1	49.6	53.5	50.6	40	105.7
Nebraska No. 60.....	6250	26.8	80.8	51.5	45.2	63.1	60.5	57.0	52.4	72	108.8
"Station Red".....	6467		72.4	47.7	42.9			55.6	58.7	32	94.7
Banat (selection).....	6676		72.8	49.2	44.0			56.6	58.7	32	96.4
Sherman.....	4430				32.7	53.2	39.1	43.3	50.6	40	85.6
Beloglina.....	1543						60.1	60.1	43.7	15	137.5
Do.....	1667	31.0	83.8	49.4	50.3	64.4	53.3	57.1	52.4	72	109.0
Kanred.....	5146	29.8	78.3	48.4	49.8	62.8	48.1	54.4	52.4	72	103.8
P-1066.....	5879	28.9						28.9	29.8	9	97.0
P-1068.....	5880	29.8						29.8	29.8	9	100.0
"Tenmarq".....	6936					50.5	38.4	44.6	52.4	31	85.1
"Kanmarq".....	6937					54.9	45.0	50.1	52.4	31	95.6
Minard.....	6690					61.7	57.9	59.9	52.4	31	114.3
Hussar.....	4843				28.4	47.8		40.8	54.7	25	74.6
Blackhull.....	6251		61.8	40.7	23.7	52.3	36.6	45.0	55.6	63	80.9
Malakof (selection).....	6680			50.2	50.7	65.3	56.3	56.8	50.5	51	112.5
Iobred.....	6934					59.2	48.6	54.1	52.4	31	103.2
Hornblende X Sum-mer Club.....	445	28.8						28.8	29.8	9	96.6
Baeska.....	6156	25.9	70.8	39.7	29.9			43.6	52.4	41	83.2
Padui.....	6153	30.0	81.8	57.2	50.2	66.2	64.1	60.5	52.4	72	115.5
Torgova.....	1539	31.8						31.8	29.8	9	106.7
Crimean (selection).....	1443	28.0						28.0	29.8	9	94.0
Eureka.....	5170			43.7	34.6			39.6	47.5	20	83.4
Newturk.....	6935					57.8	41.7	50.0	52.4	31	95.4
Minturki.....	6155	31.1	84.2	60.9	53.8	67.4	64.3	62.3	52.4	72	118.9
Marquis X Kanred (Kansas No. 441).....							36.1	36.1	43.7	15	82.6
Marquis X Kanred (Kansas No. 449).....							42.7	42.7	43.7	15	97.7
P-1063 X Preston (Kansas No. 446).....	8027						40.3	40.3	43.7	15	92.2
SOFT RED WINTER											
Minhardi.....	5149	37.4	84.3	67.4	55.6	70.0	69.7	66.0	52.4	72	126.0
Buffum No. 17.....	3330	33.2	83.5	57.5	57.2	67.5	72.5	64.1	52.4	72	122.3
Odessa.....	6151	32.4	80.8	55.6	49.3	70.9	66.7	61.8	52.4	72	117.9
Triplet.....	5408					48.1		48.1	60.6	16	79.4
Nebraska No. 28.....	5147	23.8	68.5	43.0	34.8	54.7		47.3	54.7	57	86.5

Of the varieties grown during all six years the hardiest in order of survival are Minhardi, Buffum No. 17, Minturki, Odessa, Padui, Turkey (Minn. No. 1488; C. I. No. 6152), Beloglina (C. I. No. 1667), Nebraska No. 60, Kanred, and Montana No. 36. All of these, with the exception of the three last named, are decidedly harder than the ordinary commercial Turkey and Kharkof varieties which are widely grown in the hard red winter wheat regions. Nebraska No. 28 and Blackhull are distinctly lacking in hardiness.

The varieties grown less than six years which appear to be rather hardy are Beloglina (C. I. No. 1543), Kharkof (Macdonald College

No. 2212), Kharkof (Hays No. 2), Malakof selection (Wis. 11-825), and Nebraska No. 6.

Several varieties, including Sherman, Hussar, Blackhull, Baeska, Eureka, and Nebraska No. 28, were found to be distinctly lacking in hardiness during two or more years. The latter was grown during the first five years of the experiments in order to have a tender variety with which to compare the hardy varieties.

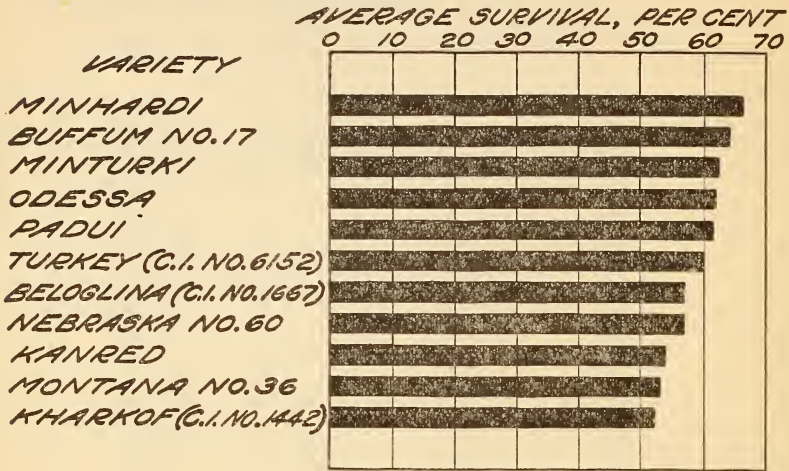


FIG. 1.—Diagram showing the weighted average survival of 11 varieties of winter wheat grown during each of the six years from 1920 to 1925, inclusive, and for 72 station years when partial killing occurred.

TABLE 9.—Average percentage of survival and annual rank of 11 varieties of winter wheat grown during each of six years at 9 to 16 stations where partial winter-killing occurred, together with the weighted average percentage of survival of each variety for the six-year period

Class and variety	C. I. No.	Survival (per cent) and rank												Weighted average of survival
		1920 (9 stations, 22 varieties)		1921 (12 stations, 18 varieties)		1922 (11 stations, 20 varieties)		1923 (9 stations, 24 varieties)		1924 (16 stations, 27 varieties)		1925 (15 stations, 28 varieties)		
		Survival	Rank	Survival	Rank	Survival	Rank	Survival	Rank	Survival	Rank	Survival	Rank	
Minhardi	5149	37.4	1	84.3	1	67.4	1	55.6	2	70.0	2	69.7	2	66.0
Buffum No. 17	3330	33.2	2	83.5	4	57.5	3	57.2	1	67.5	3	72.5	1	64.1
Minturki	6155	31.1	5	84.2	2	60.9	2	53.8	3	67.4	4	64.3	4	62.8
Odesa	6151	32.4	3	80.8	7	55.6	5	49.3	9	70.9	1	66.7	3	61.8
Padui	6153	30.0	12	81.8	6	57.2	4	50.2	7	66.2	5	64.1	5	60.5
Turkey	6152	30.7	8	83.2	5	53.9	6	47.7	10	65.8	6	63.0	7	59.6
Beloglina	1667	31.0	6	83.8	3	49.4	11	50.3	6	64.4	8	53.3	12	57.1
Nebraska No. 60	6250	26.8	20	80.8	8	51.5	7	45.2	12	63.1	9	60.5	8	57.0
Kanred	5146	29.8	13	78.3	11	48.4	13	49.8	8	62.8	10	48.1	15	54.4
Montana No. 36	5549	30.3	10	79.7	9	49.5	10	41.7	18	60.4	17	47.1	16	53.1
Kharkof	1442	29.8	14	77.3	13	50.2	8	44.3	13	60.6	16	43.7	19	52.4

Of the nonhardy varieties, Blackhull, the only one of commercial importance, had an average survival during five years of only 80.9 per cent of that of Kharkof. On the basis of these results Blackhull

can not be grown safely where severe winters are common, as it is likely to be injured during the more severe winters in Kansas and adjoining States.

Of the 10 more hardy varieties the Minturki, Kanred, and Nebraska No. 60 are of sufficient agronomic and commercial value to aid materially in reducing losses from winterkilling. The Minturki variety, however, is not well adapted to the important hard red winter area, although it yields well in southern Minnesota.

HARDY VARIETIES

MINHARDI

Minhardi shows the highest average winter survival of all varieties. It is an awnless wheat, having glabrous white glumes, soft red kernels, and strong erect stems. It has not proved to be a high-yielding variety in most field experiments, but under conditions of severe winterkilling it may outyield other varieties. It has great potential value as a parent in breeding for winter hardiness.

The Minhardi variety is a selection from a cross made at University Farm, St. Paul, Minn., in 1902, between Odessa (Minn. No. 558) and Turkey (Minn. No. 829). The wheat now known as Minhardi was increased and distributed for testing on farms about 1919, after it had shown promise in experiments, but it probably is not grown commercially now, as it is not equal to Minturki in yield or quality.

MINTURKI

The Minturki variety has the third highest percentage of survival. It is a bearded wheat having glabrous white glumes and semihard red kernels. It has many of the characteristics of the Turkey variety, but is slightly taller and has longer kernels and is resistant to stem rust. In some seasons it has kernels of rather soft texture, but usually it is of excellent bread-making value, as determined by experimental baking tests. Minturki has given good yields in experiments in Minnesota and is now one of the leading winter wheats grown in that State.

Minturki is a selection made at the Minnesota Agricultural Experiment Station from the same hybrid from which Minhardi was selected, and it was increased and distributed at the same time.

BUFFUM No. 17

The Buffum No. 17 variety ranked second in winter survival. In general, it has shown its greatest hardiness in the semiarid sections. This variety has awnless spikes, glabrous white glumes, and soft red kernels. It is a late-maturing variety and probably largely for this reason has produced relatively low yields. It has yielded best in Wyoming, but even there has not equaled Kanred and Kharkof. Buffum No. 17 is a soft red winter wheat, of good milling and baking quality for that class, but it is not equal to the hard red winter varieties. It is grown on farms only to a slight extent, if at all, at the present time.

Buffum No. 17 originated from a single plant found in a field of Turkey wheat by B. C. Buffum, Worland, Wyo., who distributed it in 1912 as a hardy winter variety.

ODESSA

Odessa was the fourth hardiest variety in these experiments and is a late-maturing variety having awnless spikes with glabrous brown glumes and soft red kernels. Partly because of its late maturity Odessa has produced low yields in most experiments. It is of good milling and baking quality for a soft red winter wheat. Although in itself of little value in reducing the amount of winterkilling, the value of Odessa in breeding wheats for winter hardiness is shown by the survival percentages of Minhardi and Minturki which are selections from a hybrid between Odessa and Turkey.

The Odessa variety was introduced into the United States many years ago, apparently from Russia. The strain tested in these experiments is a selection made at University Farm, St. Paul, Minn., from a lot of Odessa wheat (Minn. No. 943) obtained in Minnesota under the name of Berg. This selection (C. I. No. 6151) is believed to be slightly harder than the ordinary Odessa variety.

PADUI

The Padui variety, which ranked fifth in winter survival, is a rather late maturing variety having long-awned spikes, glabrous brown glumes, and semihard red kernels. Although not so late as Buffum No. 17 and Odessa, it matures too late to produce good yields under most conditions. In spite of its relative hardiness the Padui variety does not seem to offer as much promise for growing under severe winter conditions or as a parent in breeding for hardy wheats as the varieties previously mentioned.

The strain of Padui (Minn. No. 1491) used in these experiments is a selection made at University Farm, St. Paul, Minn., from the Padui variety probably originally imported from Russia by the United States Department of Agriculture, which in 1900 obtained its first sample of Padui wheat from the estate of Narishkin, near Padui, in Saratov Government, Russia.

TURKEY (MINN. No. 1488; C. I. No. 6152)

This strain of Turkey has awned spikes, glabrous white glumes, and hard red kernels. It appears to be identical with the ordinary Turkey or Kharkof except in being somewhat harder and in having harder kernels under Minnesota conditions. This wheat should be of value in some sections where the winters are fairly severe. It is earlier but not so hardy as the other varieties previously described and usually yields less than Minturki in Minnesota and where much winterkilling occurs.

The original seed of this strain of Turkey was obtained by the Minnesota Agricultural Experiment Station from Northrup, King & Co., seedsmen, some years ago. The extent of the commercial culture of the original seed is not known, and this selected strain has not been distributed for commercial growing.

BELOGLINA (C. I. No. 1667)

This Beloglina strain ranked seventh in hardiness among the 11 varieties grown during the six years from 1920 to 1925, inclusive. In 1925 another strain of Beloglina (C. I. No. 1543) was shown to have

even greater hardiness. The Beloglina is nearly identical with Turkey except in having longer beaks and slightly harder kernels. It is of good milling and baking quality. Beloglina has been found to be somewhat hardier than Kharkof in these and other experiments, but it usually yields slightly less than Turkey, Kharkof, and Kanred. It is of value in breeding because of its high quality combined with some hardiness. Beloglina wheat was introduced from Russia by the United States Department of Agriculture. It is not known to be grown on farms in this country now.

KANRED

The Kanred variety differs from Turkey and Kharkof principally in having longer beaks and in being resistant to several forms of stem and leaf rust. It has outyielded Turkey and Kharkof in the southern half of the Great Plains area and is about equal to those varieties in milling and baking quality. These and other experiments show Kanred to be slightly hardier than Kharkof. This increased hardiness sometimes is a factor responsible for the higher yields of Kanred in comparison with Kharkof and Turkey.

Kanred wheat is a selection from the Crimean variety made at the Kansas Agricultural Experiment Station in 1906. It was distributed about 1917 and is now widely grown in Kansas, Nebraska, and adjoining States.

NEBRASKA No. 60

The Nebraska No. 60 ranked eighth in hardiness. It can not be distinguished in appearance from Turkey and Kharkof. It has outyielded these varieties and has yielded about as well as Kanred in Nebraska except in rust years. It also equals these varieties in milling and baking qualities. Nebraska No. 60 shows a slightly greater average survival in the experiments than Kanred, which indicates that it is somewhat hardier than Turkey and Kharkof.

Nebraska No. 60 is a selection from Turkey made at the Nebraska Agricultural Experiment Station and distributed in 1918. It is now grown on farms in Nebraska to a considerable extent.

MONTANA No. 36

Montana No. 36 wheat is identical with Kharkof, from which it was selected, and apparently is about equal to that variety in yield and quality. The average survival, as shown in Tables 8 and 9, indicates that it is slightly better than Kharkof in hardiness.

Montana No. 36 was selected from Kharkof at the Montana Agricultural Experiment Station and was distributed in 1915 in Montana, where it is now grown.

KHARKOF (C. I. No. 1442)

Kharkof wheat has slender stems, awned spikes, glabrous white glumes, and hard red kernels. It was used as a standard variety in these experiments, because it is representative of most of the hard red winter wheat grown in this country. All wheats which show a lower percentage of survival than Kharkof are unsafe for growing in the Northern States and may be severely injured during cold winters in the central Great Plains sections.

SUMMARY

Low temperatures cause nearly as heavy losses to the wheat crop as all wheat diseases combined.

Winter wheat is more productive than spring wheat where it survives the winter. The reduction of losses due to winterkilling would result in both increased yields and more economical production. Winter injury may be reduced by the use of hardy varieties and by sowing in stubble or cornstalks, sowing in furrows, sowing at proper rates and dates, and mulching the wheat.

Forty-five winter-wheat varieties and strains were grown in uniform nurseries at 26 experiment stations in the United States and Canada during one or more of the six years from 1920 to 1925, inclusive. Eleven varieties were grown throughout the six-year period. Comparative hardiness data were obtained during 72 station years. These data show that the varieties Minhardi, Buffum No. 17, Minturki, and Odessa are considerably more cold resistant than the standard Kharkof used as a check, or control, in these experiments. Padui, Turkey (Minn. No. 1488), and Beloglina seem to be somewhat more hardy than Kharkof. Kanred and Nebraska No. 60 are probably slightly hardier than Kharkof. Nebraska No. 28 and Blackhull are much less winter hardy than Kharkof.

The results obtained in these experiments are being used as a basis for breeding wheats to combine winter hardiness with other good qualities.

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March 26, 1926

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